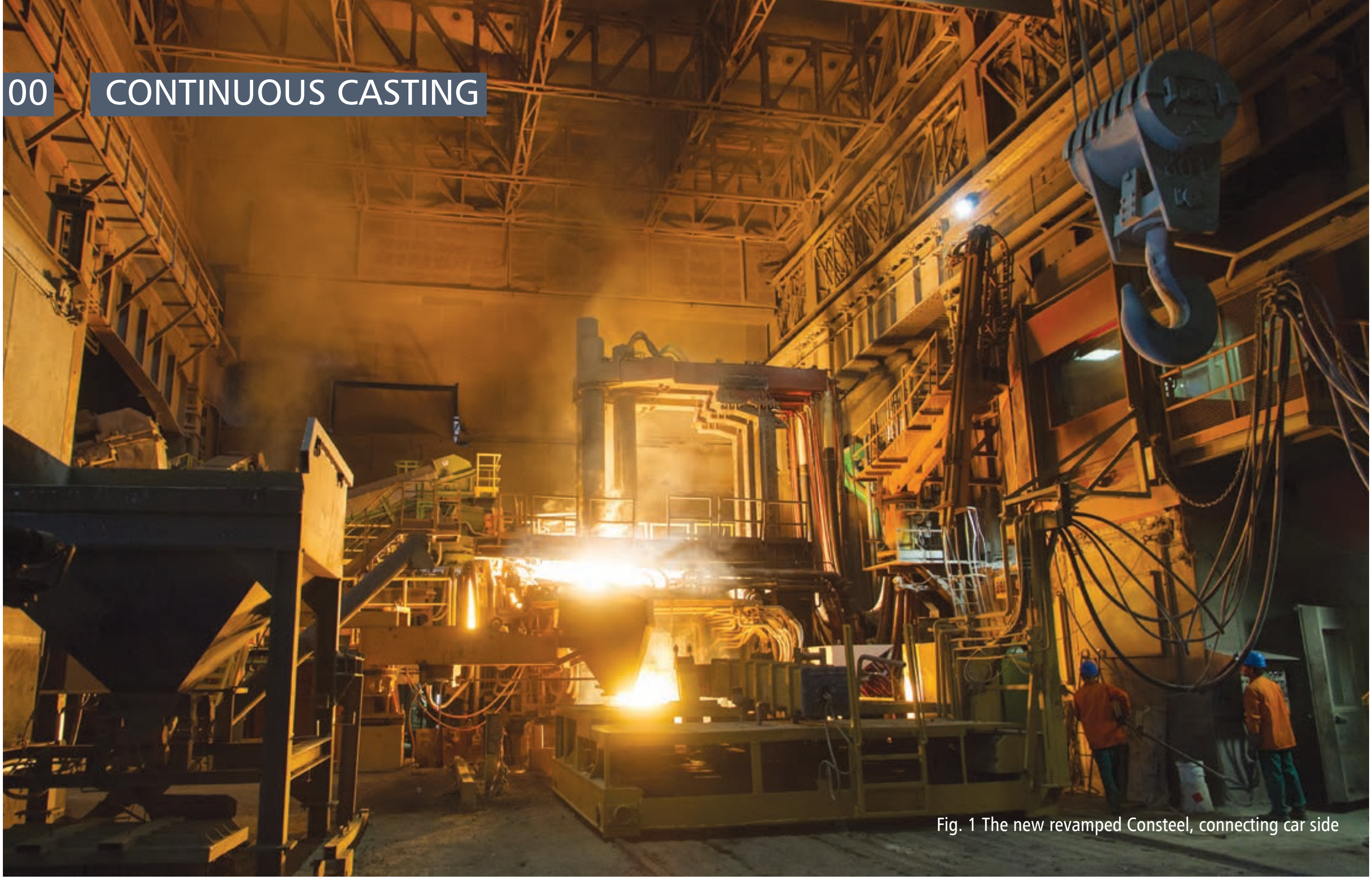

Fig. 1 The new revamped Consteel, connecting car side

Continuous scrap feeding

Ori Martin has completed the revamping and modernisation of the first European Consteel and the installation of a heat recovery system on the primary off-gas line exiting the Consteel, to recover the remaining thermal energy in the off-gas for the production of steam used for district heating and to feed an ORC turbo-generator to produce electric energy. By **N Monti*** & **U De Miranda****

WITH the aim of increasing meltshop flexibility and reduce the cost of steel production, Ori Martin has successfully commissioned and started-up the revamping of the first European Consteel together with the installation of a heat recovery system on the primary off-gas line exiting the new Consteel. The joint installation of the latest Tenova technologies has significantly improved Consteel EAF performances and, thanks to the new iRecovery system, an important amount of thermal energy is now recovered and delivered to the City of Brescia district heating grid during the winter and is fed to an ORC turbo-generator to produce electric energy for Ori Martin's internal use. The new installation allows Ori Martin to have one of the most environmentally friendly and energy-efficient steel making plants in the world.

The new Consteel

The main goals of the project included energy efficiency optimisation and improved environmental performance of the plant, which is located close to the centre of the City of Brescia, while keeping production focused on special steels and improving the quality of the product. Numerous tests have been carried out jointly by the Ori Martin team and Tenova's Engineering and Process departments. The tests have highlighted the need to think about the design of a new Consteel, which has as its objective reduced energy consumption and improved steel melting equipment operational performance.

The new Consteel project is based on the following fundamental concepts:

- rebalancing the two main components of the melting unit (Consteel and EAF) to achieve productivity efficiently and continuously;
- improve thermal exchange between EAF off-gas and scrap in different charging conditions (greater exposed surface and lower height of the scrap layer);
- improve scrap distribution as it enters the liquid steel bath (larger surface area where scrap falls in the steel bath) in order to speed up melting and reduce interference with steel bath stirring;
- keep the connecting car pan inserted inside the EAF for any furnace tilting angle, so as to have the metallic scrap charging and the electrical power-on to the EAF

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* Tenova S.p.A. Via Gerenzano, 58 - 21053 Castellanza VA (Italy) +39 0331 444111 nicola.monti@tenova.com,
** Ori Martin S.p.A. Via Cosimo Canovetti, 13 - 25128 Brescia BS (Italy) +39 030 39991uggero.demiranda@orimartin.it

Fig 2.The new revamped Consteel, offtake hood side.

electrodes starting together at the earliest opportunity;

- reduce ambient air suction inside the Consteel and the primary off-gas line by increasing the efficiency of the Consteel seals and by better controlling ambient air intake through the dynamic seal;
- maintain high temperatures of EAF off-gas;
- reduce the off-gas flow rate in the primary off-gas line and, as a consequence, reduce electrical consumption to the fume treatment plant;
- improve the conditions of the off-gas at the inlet of the heat recovery system installed on the primary off-gas line.

The correct operation of the process is entrusted to a completely new and innovative supervisory and control system that is capable of interacting consistently with the management systems of other production units. This type of process control is characteristic of Tenova's iSteel, a product designed for the continuous technological improvement of the steel production cycle on a global basis. Automatic spillage control or TAT (Tenova Auto Tapping), has been implemented to control EAF slag flow through the EBT during steel tapping into the ladle and to minimise human intervention during this operation. The melting process in Ori Martin is rather atypical when compared with the other Consteel EAFs. Why? Because it employs limited oxygen and carbon injection and that leads to a modest quantity of energy in the off-gases. The main objective of the revamping is to maximise off-gas recovery by improving heat transfer to the scrap in the heating tunnel and by optimising the conditions of the gases at the tunnel's exit to properly feed a downstream recovery system. The transfer of heat to the scrap is improved by increasing the scrap-exposed surface through the installation of the widest conveyor (2400mm) compatible with the existing EAF geometry. At the same time the new Consteel drive allows increasing the conveying speed by 2m/min. The changes will result in a reduction of the average scrap height from 800mm to 500mm and that will boost the average scrap charging temperature at the EAF. The hoods of the heating tunnel are being completely redesigned applying the results of a CFD analysis based on actual off-gas flow data. The aspect ratio of the hoods has been changed as they are wider and lower, while the overall section has been reduced by about 20%. The energy recovery efficiency both in the Consteel tunnel and in the downstream iRecovery improves dramatically with the increase of the temperature of the gases. The new Consteel implements a completely redesigned set of seals to minimise the admission of bleed air. The sealing chamber at the open end of the conveyor (a dynamic seal) has been reconfigured to achieve the desired result. To seal the gap between the heating tunnel and the EAF shell a new circular flange, divided in to two independent sectors, is installed. The position of the upper flange can be regulated to adjust the quantity of post-combustion air to assure the complete combustion of CO and H_2? generated into the EAF. Both flange sections are retractable to give the needed clearance for shell changeover between campaigns. The improvement of the seals and the changes in the design of the dynamic seal allow fumes temperatures to be significantly higher than those observed before both inside the tunnel and at the tunnel's exit. To reduce the dust load in the fumes sent to the waste heat boiler and improve the deposition of metallic dust particles on the scrap layer, the offtake hood has also been redesigned, increasing both the horizontal section and the height to reduce the vertical speed of the fumes and increase their residence time. The EAF platform cradles are replaced to match the EAF tilting axis and the flange axis, and the connecting car is also improved so that it can be left inserted throughout the process, eliminating any delays.

The iRecovery

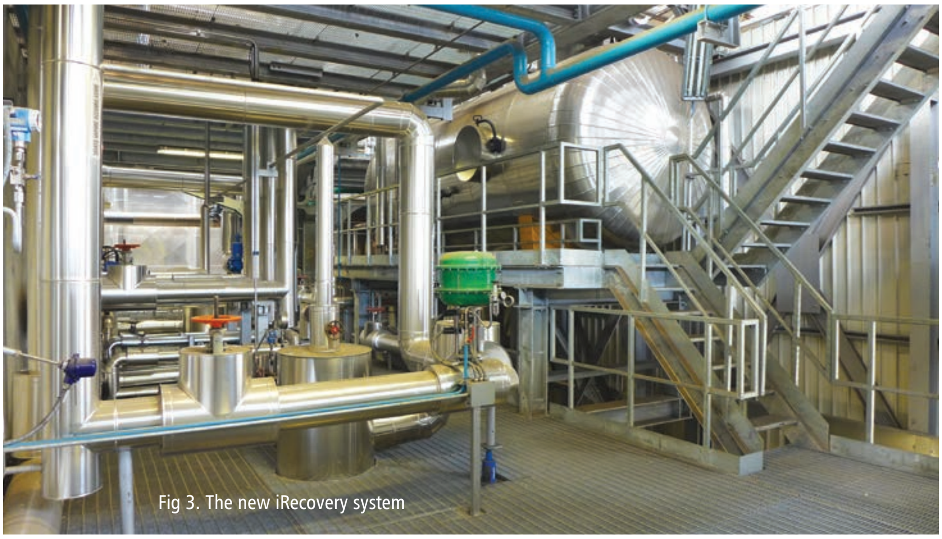

Fig 3. The new iRecovery system

Fig 4. The new iRecovery system, heat recovery section

The heat recovery system, iRecovery, has been running successfully since early 2016. The system, installed downstream of the new Consteel EAF furnace, is tasked to recover some of the energy contained in the fumes generated during the EAF production cycle. The energy extracted from the fumes converts the recirculation water of the cooling circuit into steam. This is made possible thanks to the use of cooling water at boiling conditions that, circulating and absorbing energy, will be subject to partial phase change generating saturated steam. During winter the steam produced is sent to a heat exchanger dedicated to district heating for the town of Brescia and managed by A2A Group. During summer months, the steam produced is used to feed an ORC (Organic Rankine Cycle) turbo-generator, supplied by Turboden for the production of electricity for internal use. The heat exchanger, otherwise known as a waste heat boiler, consists of a single convective exchange unit, operating between fumes temperatures of approximately 500-550°C down to a temperature of approx. 200°C. However, since the EAF process generates heat loads that are not constant over time (scrap melting, liquid steel refining and superheating, tapping, EAF preparation), the fumes temperature has a significant variability over time. The recovery of heat and its transfer to the users is carried out according to a continuous cycle where water, coming from the degasser, evaporates into the waste heat boiler, cools down in the heat exchangers of the users and is then sent back in the form of condensate to the degasser, thus closing the thermal cycle.

The system is basically divided into the following sections:

Heat recovery section, starting from the new off-gas duct, in parallel to the existing off-gas duct to the quenching tower, which branching from the refractory-lined underground tunnel (upstream of the quenching tower), conveys the hot fumes in the heat recuperator, waste heat boiler, and then to the primary existing off-gas line downstream of the quenching tower.

The waste heat boiler consists of a steam generator with natural circulation water tube bundles fitted with:

- casing, namely the fumes flow chamber that contains the convective heat exchange units;
- evaporators consisting of bundles of vertical tubes crossed by the off-gas inside which the water (liquid phase) coming from the steam drum undergoes a partial evaporation;
- steam drum which consists of a cylindrical pressure vessel installed above the recuperator in which the liquid water is in balance with the steam. From the bottom of the steam drum come out both down take pipes that go to the evaporators and the upwards pipes coming from the same evaporators;
- economisers consisting of bundles of vertical tubes inside which water is coming from the degasser. The economiser tubes are crossed by the off-gas. In the economisers, water temperature is raised from about 105°C to a temperature close to boiling point, at a defined pressure, in the steam drum; thanks to the economizers the temperature of the off-gas coming out from the evaporators can be further reduced;
- automatic cleaning system of the recuperator that allows the cyclical separation of dust deposited on the surfaces of the exchange units inside the heat machine;
- dust extraction system to collect and convey the dust separated in the recuperator up to a storage bin.

Heat exchange section with A2A district heating system: the steam coming from the steam accumulation section is transferring, by condensing, its energy to the water of the district heating grid of A2A thanks to a heat exchange unit that consists of two condensing heat exchangers operating in parallel. A flash tank inside conveys all the condensate, and an additional condenser condenses back the flash steam and exchanges it the same district

Fig 5.The new iRecovery system, A2A exchange section

Fig 6. he ORC turbo-generator (by courtesy of Turboden)

heating water?. All the condensate is then subsequently sent to the degasser through a booster pump group.

ORC section: for converting recovered thermal energy into electrical energy. Consists essentially of a turbo-generator with Organic Rankine Cycle (ORC) that using the steam from the recovery section and converts the recovered thermal energy into electrical energy.

Water supply section: composed of a thermo-physical degasser with turret which carries out a dual role: first it ensures continuity of supply to the recuperator in case of non-supply of make-up water; second it allows the elimination of gases dissolved in the make-up water.

The water in the degasser is drawn from a group of feed pumps and transferred to the steam drum of the recuperator; the pump group is provided with a level control valve that regulates the flow of water depending on the level of water in the steam drum.

Steam pressure accumulation and reduction section: the steam produced by the recuperator is conveyed to a steam accumulator that accumulates thermal energy. In its outlet, on the delivery lines to the end users, there are some thermal expansion valves that reduce steam pressure and ensure that it is below the pre-set value. Furthermore, between the steam drum and the accumulator there is a valve that prevents steam pressure below a pre-determined value.

Operating results

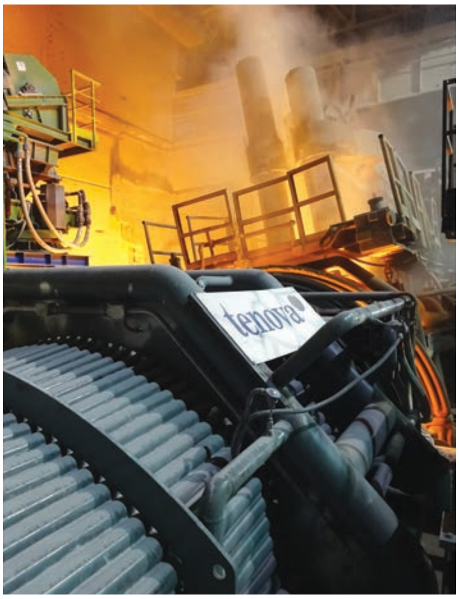

Fig 7. The new revamped Consteel in operation, tapping phase

Considering the first period of operation from the start-up of the new Consteel EAF, followed by the commissioning and start-up of the iRecovery system, analysis of operative data already shows good performances by these two integrated systems. The performances of the new Consteel EAF are measured calculating a cost index that considers energy and media consumptions: the expected reduction of more than 8% of this cost index compared with the previous average values is confirmed. As an additional performance figure, furnace productivity is increased by more than 13%, exceeding all expectations and reaching outstanding reference value in the production of steel via EAF. The performance figures mentioned above are the average of a long production period beginning with the start-up of the furnace. Further developments and continuous improvement are still on-going in order to exploit the high potential demonstrated by the system to exceed expected values. The operation achieved with the new Consteel EAF is the base from which to reach the expected performance of the iRecovery system with a view to recovering thermal energy from the primary off-gas in the range of 90 kWh/tgb – and more that will be available for the district heating and for the ORC turbo-generator. Thanks to a continuous commitment to optimise plant tuning, the steam flow rate is now controlled based on the average thermal load of the fumes expected and can now be kept uniform over tat to tap time? [tap-to-tap] due to the thermal buffer of the steam accumulator. After the first period of operation, the average results of the iRecovery system during more than one year of operation show that the amount of energy recovered from the off-gas and transformed in to ready-to-use thermal energy is in line with the expected results. The overall integrated Consteel EAF and iRecovery system has performed outstandingly in terms of steel production. With the performance results now fully integrated, the whole system is steady and consistent and gives ORI Martin the opportunity to exploit a new additional lever (level?) for more flexible and efficient operation. The potential demonstrated by the system cries out for further development to optimise performance and costs in different scenarios. The revamping and optimisation have lead to Ori Martin being one of the most flexible, efficient and environmentally-friendly steel making plants in the world. ■

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